

NONFELTING WOOL AND ANTIFELT FINISHING PROCESS

BACKGROUND OF THE INVENTION

The invention relates to nonfelting wool and a process for antifelt finishing by treating the wool with a plasma and also to an aftertreatment with a specific finishing agent.

The textile processing industry has a particular interest in reducing  
5 the felting tendency of wool, especially of raw wool or unprocessed wool. The felting of wool is customarily reduced by finishing with specific auxiliaries.

Isocyanates, especially self-dispersing isocyanates, have long been used as auxiliaries for the antifelt finishing of textiles. However, self-  
10 dispersing isocyanates, the use of which has become preferred, do not always provide a completely satisfactory antifelt finish on the treated textiles when used alone.

DE-A 198 587 34 and DE-A 198 587 36 disclose the antifelt finishing of wool by combination of a plasma treatment with an after-  
15 treatment using such self-dispersing isocyanates. To apply these self-dispersing isocyanates to the wool, it is first necessary to prepare aqueous dispersions. Since such dispersions have only a very limited shelf life, due to the ensuing crosslinking reaction of the isocyanate end groups in water, they have to be prepared relatively shortly before use for wool treatment.

DE-A 2 035 172 describes a process for the antifelt finishing of wool in which the wool is treated with a polyurethane latex liquor and the fabric is dried and subsequently cured. To be able to prepare latices suitable for finishing, organic solvents and external emulsifiers have to be used at the prepolymerization stage. The prepolymers initially obtained are  
20 subsequently fully polymerized by addition of a chain extender.

DE-A 26 57 513 discloses a process for the antifelt finishing of wool using reaction products of polyisocyanates with hydroxyl-functional compounds.

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DD 5381 describes a process for preparing hydrophilic basic polyurethanes from diisocyanates, diprimary aliphatic glycols containing one or more basic tertiary nitrogen atoms in open chain, and diprimary glycols without basic nitrogen. Possible applications mentioned for such products are very generally films, fibers, sizing and hand modifying agents, animalizing agents, and sizing agents for paper.

DD 5379 describes a process for preparing hydrophilic basic polyurethanes from diisocyanates and nitrogenous glycols containing, in the chain between the hydroxyl groups, one or more tertiary nitrogen atoms in which third valencies are saturated by monovalent alkyl groups that do not have more carbon atoms than the shortest carbon chain between a hydroxyl group and tertiary nitrogen. Possible applications mentioned for such products are very generally films, fibers, sizing and hand modifying agents, animalizing agents, and sizing agents for paper.

DD 5367 describes very specific polyurethanes prepared from diisocyanates and N,N'-di[oxyalkyl]piperazines.

It is an object of the present invention to provide an improved process for the antifelt finishing of wool.

#### SUMMARY OF THE INVENTION

The present invention accordingly provides a process for antifelt finishing of wool comprising

- (a) exposing wool to a plasma in a pretreatment, and
- (b) treating the plasma-treated wool with an aqueous dispersion of cationic polyurethanes.

#### DETAILED DESCRIPTION OF THE INVENTION

The plasma treatment of the wool in step (a) of the process of the invention is effected either as a low temperature plasma treatment at reduced pressure or as a corona treatment at normal pressure.

The low temperature plasma treatment is extensively described in DE 196 16 776 C1 (counterpart of U.S. Patent 6,103,068, hereby expressly incorporated by reference). The wool is exposed to a radiofrequency discharge of a frequency of 1 kHz to 3 GHz and a power

density of 0.003 to 3 W/cm<sup>3</sup> at a pressure of 10<sup>-2</sup> to 10 mbar for a period of 1 to 600 sec in the presence or absence of non-polymerizing gases. The process is preferably carried out under a pressure of 0.1 to 1 mbar and for a period of 2 to 5 minutes.

- 5           The actual low temperature plasma is generated by feeding in electromagnetic radiation in the frequency range of 1 kHz to 3 GHz. In a preferred variant, the low temperature plasma is generated via a microwave discharge of 1 to 3 GHz (the power density at the outcoupling is especially 0.1 to 15 W/cm<sup>2</sup>). The electromagnetic radiation can be  
10       supplied continuously or pulsed. A pulsed high frequency discharge having a pulsing frequency of up to 10 kHz is especially advantageous.

- When non-polymerizing gases are additionally used as plasma process gases, they are introduced into the plasma treatment space at a flow rate of up to 200 l/h. Useful non-polymerizing gases are in particular  
15       oxygen, nitrogen, noble gases, especially argon, air, or mixtures thereof.

- The design and construction of a low temperature plasma reactor are known. Preference is given to using an electrodeless reactor having an outcoupling for microwaves. The wool to be treated is preferably placed underneath the outcoupling unit. The distance of the wool from the  
20       outcoupling unit is preferably 1 to 30 cm, especially 2 to 10 cm. After the wool to be treated has been introduced into the reactor, the reactor is suitably evacuated with vacuum pumps in such a way that the pressure during the plasma treatment is in the range of 10<sup>-2</sup> to 10 mbar, preferably 0.1 to 1 mbar. A continuous flow-through operation is preferably carried  
25       out by applying specific vacuum locks that make it possible for the material to enter and exit without leakage.

- Alternatively to this embodiment of the low temperature plasma treatment under low pressure, the wool can also be subjected to a corona treatment at a pressure in the range of 100 mbar to 1.5 bar, preferably at  
30       atmospheric pressure. The corona treatment is described in detail in DE-A 198 587 36 (counterpart of U.S. Patent 6,242,059, hereby incorporated by reference).

The corona treatment subjects the wool to a high frequency discharge having a power density of customarily  $0.01$  to  $5 \text{ Ws/cm}^2$  for a period of 1 to 60 seconds (preferably 2 to 40 seconds, particularly 3 to 30 seconds) in the presence or absence of non-polymerizing gases.

- 5 Suitable non-polymerizing gases are air, oxygen, nitrogen, noble gases, or mixtures thereof.

The actual plasma is generated by applying an alternating voltage of 1 to 20 kV in the frequency range between 1 kHz to 1 GHz (preferably 1 to 100 kHz) to electrodes, one or both poles being provided with an  
10 insulator material. The alternating voltage can be supplied either continuously or with individual pulses or with pulse trains and pauses in between.

The design and apparatus configurations of a corona reactor are known and described, for example, in DE-A 197 31 562. The corona  
15 treatment is preferably carried out via electric discharges in the atmospheric pressure region, for which the wool to be treated is initially introduced into a sealed, tight treatment housing, charged there with the working gas, i.e., the above-mentioned non-polymerizing gas, and subsequently exposed to an electric barrier discharge in a gap between  
20 the two treatment electrodes. The distance of the wool material from the treatment electrodes is 0 to 15 mm, preferably 0.1 to 5 mm, particularly 0.3 to 2 mm. The treatment electrodes are preferably constructed as rotatable rolls either or both of which are coated with electrically refractory dielectric material.

25 Performing the corona treatment at a pressure in the range from 100 mbar to 1.5 bar, preferably at atmospheric pressure, has the advantage over the low pressure plasma treatment at  $10^{-2}$  to 10 mbar that the equipment needed is very much less complicated than in the case of the low pressure treatment. Vacuum pumps are not required, nor is it  
30 necessary to fit special vacuum locks.

The special effect of the plasma treatment in step (a) of the process of the invention might be explained as follows. The liquid present in the

fiber desorbs from the fiber surface as water vapor/gas during the process. High energy electrons, ions, and also highly excited neutral molecules or radicals are formed and act on the surface of the fiber, the water vapor desorbed from the fiber ensuring that particularly reactive particles are  
5 formed in the immediate vicinity of the respective fiber surface and these particularly reactive particles act on the surface.

Following the plasma treatment in step (a) of the process according to the invention, the wool is treated in step (b) with an aqueous solution of cationic polyurethanes.

10 These cationic polyurethanes have a weight average molecular weight of at least 14,000, preferably at least 16,000, particularly preferably at least 18,000, especially at least 20,000. The upper limit of the molecular weight is customarily 200,000, preferably 180,000, particularly preferably 150,000.

15 The cationic polyurethanes are obtainable by reaction of

(i) organic polyisocyanates of the general formula (I)



where

p is from 1.5 to 5, and

20 Q is an organic radical, and

(ii) one or more bis- and/or polyhydroxy compounds containing at least one tertiary nitrogen atom and at least two hydroxyl groups, wherein the cationic character of the polyurethane is generated by subsequent protonation or alkylation of the tertiary nitrogen atoms.

25 Optionally, the cationic polyurethanes used according to the invention are prepared by additionally using

(iii) one or more bis- and/or polyhydroxy compounds that contain no nitrogen atoms and have molecular weights of 62 to 5,000.

Useful organic polyisocyanates (i) of the general formula (I)

30  $Q[NCO]_p, \quad (I)$

where Q and p are each as defined above and include, for example, the following three types:

- (1) aliphatic, cycloaliphatic, araliphatic, and aromatic polyisocyanates,
- (2) aliphatic, cycloaliphatic, araliphatic, and aromatic polyisocyanates that contain isocyanurate and/or uretidione and/or allophanate and/or biuret and/or oxadiazine structures, and
- 5 (3) isocyanate prepolymers that are obtainable by reaction of aliphatic, cycloaliphatic, araliphatic, and aromatic diisocyanates and polyesters and/or polyethers.

The aliphatic, cycloaliphatic, araliphatic, and aromatic polyisocyanates (2) with isocyanurate and/or uretidione and/or allophanate and/or  
10 biuret and/or oxadiazine structures are preparable according to conventional prior art processes from corresponding aliphatic, cycloaliphatic, araliphatic, and aromatic diisocyanates.

The isocyanate prepolymers (3) are reaction products of aliphatic, cycloaliphatic, araliphatic, and aromatic diisocyanates and polyesters  
15 and/or polyethers, which optionally may contain unconverted, free polyisocyanates.

Illustrative examples of aliphatic, cycloaliphatic, araliphatic, and aromatic diisocyanates useful as type (1) or for preparing types (2) and (3) are 1,4-diisocyanatobutane, 1,6-diisocyanatohexane, 1,5-diisocyanato-2,2-  
20 dimethylpentane, 2,2,4-trimethyl-1,6-diisocyanatohexane, 1,3- and 1,4-diisocyanatocyclohexane, 1-isocyanato-1-methyl-4-isocyanatomethylcyclohexane, 4,4'-diisocyanatocyclohexylmethane, 2,4- and 2,6-diisocyanato-1-methylbenzene, 4,4'-diisocyanatodiphenylmethane, or any mixtures of these diisocyanates.

25 Preferred examples of modified diisocyanates (2) are trimerization products of hexamethylene diisocyanate and of its biuret-based derivatives, mixtures of the uretidione and the trimerization products of hexamethylene diisocyanate, and the uretidione of toluene diisocyanate.

Preferred examples of the isocyanate prepolymers (3) are reaction  
30 products of toluene diisocyanate or of hexamethylene diisocyanate with polyhydric alcohols, for example, of toluene diisocyanate with trimethylolpropane.

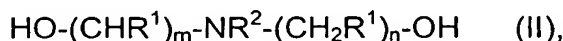
Preference is given to organic polyisocyanates of the general formula (I)



where

- 5     p     is from 1.5 to 5 (especially 2), and  
       Q     is an aliphatic hydrocarbon radical having 2 to 18 (especially 6 to 10) carbon atoms, a cycloaliphatic hydrocarbon radical having 4 to 15 (especially 5 to 10) carbon atoms, an aromatic hydrocarbon radical having 6 to 15 (preferably 6 to 13) carbon atoms, or an  
 10     araliphatic hydrocarbon radical having 8 to 15 (preferably 8 to 13) carbon atoms.

Preferred bis- and/or polyhydroxy compounds (ii) are those of the general formula (II)



15     where

n and m are independently from 1 to 6,

- R<sup>1</sup>     is in each case independently hydrogen or a straight-chain or branched C<sub>1</sub>-C<sub>4</sub>-alkyl radical wherein, along the (CHR<sup>1</sup>)<sub>n</sub> and (CHR<sup>1</sup>)<sub>m</sub> alkylene chains, R<sup>1</sup> can alternately from carbon atom to  
 20     carbon atom be not only hydrogen but also a straight-chain or branched C<sub>1</sub>-C<sub>4</sub>-alkyl radical, and  
       R<sup>2</sup>     is straight-chain or branched C<sub>1</sub>-C<sub>10</sub>-alkyl (especially C<sub>1</sub>-C<sub>6</sub>-alkyl), C<sub>1</sub>-C<sub>10</sub>-cycloalkyl (especially C<sub>5</sub>-C<sub>6</sub>-cycloalkyl), C<sub>6</sub>-C<sub>12</sub>-aryl (especially phenyl), or a -CH<sub>2</sub>)<sub>r</sub>-OH radical in which r is from 1 to 6.

- 25     Illustrative examples of bis- and/or polyhydroxy compounds (ii) of the general formula (II) are N-methyldiethanolamine, N-ethyldiethanolamine, N-butyldiethanolamine, N-methyldipentanolamine-1,5, N-ethyl-dipentanolamine-1,5, triethanolamine, reaction products of fatty amines with two moles of ethylene oxide or propylene oxide or alkoxylation  
 30     products of the aforementioned compounds, preferably of tris[2-(2-hydroxyethoxy)ethyl]amine.

Illustrative examples of bis- and/or polyhydroxy compounds (iii) that contain no nitrogen atoms and have molecular weights of 62 to 5,000 are ethylene glycol, propanediol-1,2, propanediol-1,3, butanediol-1,4, butanediol-1,3, butanediol-2,3, butanediol-1,2, butenediol-1,4, butynediol-1,4, pentanediol-1,5, neopentyl glycol, hexanediol-2,5, hexanediol-1,6, 3-methylpentanediol-1,5, 2,5-dimethylhexane-2,5-diol, octadecanediol-1,12, diethylene glycol, dipropylene glycol, triethylene glycol, tripropylene glycol, tetraethylene glycol, tetrapropylene glycol, and also further higher polyethylene and polypropylene glycols, glycerol, trimethylolpropane, 2-hydroxymethyl-2-methyl-1,3-propanediol, 1,2,6-hexanetriol, or pentaerythritol.

It is further possible to use polyethers and polyesters having a weight average molecular weight of up to 5,000 (preferably up to 3,000, particularly preferably up to 2,000) as component (iii). Polyethers are obtainable from the above-mentioned bis- and/or polyhydroxy compounds as starter molecules by reaction with ethylene oxide, propylene oxide, and/or butylene oxide according to known processes of the prior art. Polyesters are likewise obtainable from the above-mentioned bis- and/or polyhydroxy compounds, namely by esterification with industrially available di- or tricarboxylic acids according to known processes of the prior art.

Particularly useful cationic polyurethanes are obtained by reaction of

(i) organic polyisocyanates of the general formula (I)



where

p is from 1.5 to 5 (especially 2), and

Q is an aliphatic hydrocarbon radical having 2 to 18 (especially 6 to 10) carbon atoms, a cycloaliphatic hydrocarbon radical having 4 to 15 (especially 5 to 10) carbon atoms, an aromatic hydrocarbon radical having 6 to 15 (preferably 6 to 13) carbon atoms, or an araliphatic hydrocarbon radical having 8 to 15 (preferably 8 to 13) carbon atoms, and



- (ii) bis- and/or polyhydroxy compounds (ii) of the general formula (II)  
$$\text{HO}-(\text{CHR}^1)_m-\text{NR}^2-(\text{CH}_2\text{R}^1)_n-\text{OH} \quad (\text{II}),$$

where

n and m are independently from 1 to 6 and are especially identical  
and from 1 to 3,

$\text{R}^1$  is in each case independently hydrogen or a straight-chain or  
branched  $\text{C}_1$ - $\text{C}_4$ -alkyl radical wherein, along the  $(\text{CHR}^1)_n$  and  
 $(\text{CHR}^1)_m$  alkylene chains,  $\text{R}^1$  can alternately from carbon  
atom to carbon atom be not only hydrogen but also a  
straight-chain or branched  $\text{C}_1$ - $\text{C}_4$ -alkyl radical, and

$\text{R}^2$  is straight-chain or branched  $\text{C}_1$ - $\text{C}_{10}$ -alkyl (especially  $\text{C}_1$ - $\text{C}_6$ -  
alkyl),  $\text{C}_1$ - $\text{C}_{10}$ -cycloalkyl (especially  $\text{C}_5$ - $\text{C}_6$ -cycloalkyl),  $\text{C}_6$ - $\text{C}_{12}$ -  
aryl (especially phenyl), or a  $-(\text{CH}_2)_r-\text{OH}$  radical in which r is  
from 1 to 6, especially from 1 to 3,

- and the cationic character of the polyurethanes is generated by  
subsequent protonation or alkylation of the tertiary nitrogen atoms.

Very particular preference is given to using in step (b) of the  
process according to the invention cationic polyurethanes obtained by  
reaction of

- (i) 2,4-toluene diisocyanate or 2,6-toluene diisocyanate or mixtures of  
these isomers with  
(ii) N-methyl- or N-butyldiethanolamine,  
wherein the cationic character is generated by treating the reaction  
products with one of the acids hydrochloric acid, sulfuric acid, formic acid,  
acetic acid, or propionic acid.

To prepare the cationic polyurethanes to be used in step (b) of the  
process according to the invention, the bis- and/or polyhydroxy  
compounds (ii) and optionally (iii) are customarily initially charged in an  
aprotic auxiliary solvent.

- It is advantageous to choose the amount of polyhydroxy  
compounds (ii) and optionally (iii) in such a way as to still obtain a readily  
processable cationic polymer.

Illustrative examples of aprotic solvents for the reaction are alkyl ether acetates, glycol diesters, toluene, carboxylic esters, acetone, methyl ethyl ketone, tetrahydrofuran, dimethylformamide, and N-methylpyrrolidone.

5           This initially charged solution then has added to it the organic polyisocyanate (i) with stirring. Excesses of organic polyisocyanate must be avoided in the process, since this leads to undesirable secondary reactions due to the presence of a multiplicity of tertiary amine structures from the components (ii) and optionally (iii).

10           Conventional catalysts such as dibutyltin dilaurate, tin(II) octoate, or 1,4-diazabicyclo[2.2.2]octane and/or further compounds containing tertiary nitrogen or tin and also optionally bismuth compounds or other customary polyurethane chemistry catalysts in amounts of 10 to 1,000 ppm, based on the reaction components, can be used to speed up the reaction. The  
15 reaction is carried out in the temperature range up to 130°C, preferably in the range from 20 to 80°C. The upper limit of the reaction temperature is set by the boiling point of the solvent; it can be advantageous to conduct the reaction under evaporative cooling. The reaction is monitored by determining the NCO content by titration or by measurement of the IR  
20 spectra and evaluation of the NCO band at 2260 to 2275  $\text{cm}^{-1}$  toward the end of the reaction and is complete when the isocyanate content is not more than 0.1% by weight above the value that is obtained at complete conversion under the given stoichiometry or when the NCO band has disappeared.

25           It is advantageous for the molar ratio of component (i) to component (ii) plus optional component (iii) to be set in such a way as to have an approximately stoichiometric ratio of the NCO and OH end groups present.

The polyurethanes are customarily rendered cationic in one of the following two ways:

30           First, it is possible to dilute the solution of the polyurethane as prepared with an aqueous acid after the reaction. Useful acids include, for example, hydrochloric acid, sulfuric acid, formic acid, acetic acid, or

propionic acid. Formic acid and acetic acid are preferred. This addition of an acid protonates the tertiary nitrogen atoms from component (ii) and, if used, component (iii). It is customary to use a stoichiometric amount of acid, based on the nitrogen atoms, so that ideally complete protonation is  
5 obtained. The solvent is then distilled off until the theoretical solids content is obtained.

On the other hand, it is also possible for the polyurethane prepared as described above to be converted into a polyurethane having permanent cationic charges by partial or complete alkylation. This can be  
10 accomplished according to conventional processes directly following preparation, either in organic solution or else in the aqueous state. The alkylating agents used are preferably methyl chloride, methyl iodide, dimethyl sulfate, or methyl p-toluenesulfonate.

In step (b) of the process according to the invention the aqueous  
15 dispersion of the cationic polyurethane is applied to the wool at a pH of 2 to 7, preferably 3 to 6, particularly preferably 4 to 6 and especially 4.5 to 5.5. The application temperature is customarily in the range from 20 to 80°C, preferably from 30 to 70°C, particularly preferably from 30 to 60°C.

The concentration of the aqueous dispersion of the cationic  
20 polyurethane, based on the solids content of polyurethane, in the finishing liquor is 0.5 to 75 g/l, preferably 1 to 50 g/l.

The treatment with the aqueous solution of cationic polyurethanes of the wool in step (a) is effected according to customary processes of the prior art. Suitable is, for example, a batchwise method by the exhaust  
25 process or a continuous method by dipping, roll application, padding, application of a mist or spray, or backwasher application optionally using dyeing machines, stirrers, and the like to agitate the treatment liquor. The liquor ratio can be chosen within wide limits and can be within the range of (20 to 5):1, preferably (10 to 5):1.

30 Unexpectedly, the cationic polyurethanes are very quick to exhaust onto the wool in step (b) of the process according to the invention. This is all the more surprising as, at the slightly acidic pH customarily used for the

aqueous liquor, the wool itself has a cationically charged surface, whereby the cationic polyurethanes should actually be repelled, which would result in worse exhaustion characteristics for the polyurethanes.

The treatment in step (b) is optionally followed by a further after-treatment step (c) in which the wool is treated with further auxiliaries and additives. Useful such auxiliaries and additives include, for example, flow control agents, levelling agents, surfactants, deaerators, wetting agents, distancing agents, exhaustion auxiliaries, and fixatives.

The cationic polyurethanes used in the process of the invention have incomparably better stability in aqueous dispersion than the self-dispersing isocyanates known from DE-A 198 587 34 and DE-A 198 587 36. The corresponding dispersions therefore have far longer use lives and can be prepared and utilized with long lead times.

The present invention further provides the nonfelting wool, characterized in that the wool

- (a) is exposed to a plasma in a pretreatment, and
- (b) treated with an aqueous dispersion of cationic polyurethanes.

The two steps (a) and (b) are subject to the above remarks for the process.

The wool used in the process of the invention may be selected from a very wide range of wool materials, for example, raw wool after the raw wool wash, dyed or undyed wool slubbing, dyed or undyed wool yarn, roving, drawn-loop knits, formed-loop knits, wovens, or cloths. The water content of the wool is customarily 4 to 40% by weight, preferably 5 to 30% by weight, particularly preferably 6 to 25% by weight, especially 8 to 15% by weight.

The wool of the present invention, finished with cationic polyurethanes, differs substantially from wool finished with self-dispersing isocyanates. The self-dispersing isocyanates known from DE-A 198 587 34 and DE-A 198 587 36 are compounds that are located in the low molecular weight range and are prepared, for example, by reaction of organic diisocyanates such as diisocyanatobutane with monofunctional

polyalkylene oxide alcohols, amines, or thiols. These self-dispersing isocyanates crosslink on the surface of the wool in the presence of water. The NCO end groups of the polyisocyanates react with the water to detach CO<sub>2</sub> and to form longer chains through formation of urea moieties as

5 bridge members between pairs of isocyanate molecules. The crosslinked longer chains thus have relatively many urea moieties and only very few urethane bonds. By contrast, polyurethanes having the stated high molecular weights have a very large number of urethane bonds in the main chain. Due to the higher molecular weights, the end group

10 concentration is relatively low and the end groups themselves are difficult to access. Crosslinking of the small number of NCO end groups possibly present under the influence of water is therefore hardly likely.

The following examples further illustrate details for the process of this invention. The invention, which is set forth in the foregoing disclosure,

15 is not to be limited either in spirit or scope by these examples. Those skilled in the art will readily understand that known variations of the conditions of the following procedures can be used. Unless otherwise noted, all temperatures are degrees Celsius and all percentages are percentages by weight.

20

### EXAMPLES

#### I Preparation of cationic polyurethanes

##### Polyurethane 1 (inventive):

174.5 g of toluene diisocyanate (mixture of 2,4- and 2,6-isomer in a ratio of 20:80; 1.003 mol) are added to a solution of 119.2 g of N-methyl-

25 diethanolamine in 250 g of acetone at room temperature over the course of 1.5 hours. An infrared spectrum is then recorded to check if there are still any free isocyanate groups left over. If this is not the case, 707 g of water and 60 g of glacial acetic acid are added as a mixture. This results in the formation of a homogeneous clear liquid, from which the solvent is

30 distilled. The distillation is terminated once the solids content is 29%.

Polyurethane 2 (inventive):

168.8 g of toluene diisocyanate (mixture of 2,4- and 2,6-isomer in a ratio of 20:80; 0.97 mol) are added to a solution of 119.2 g of N-methyldiethanolamine in 250 g of acetone at room temperature over the course of 1.5 hours. An infrared spectrum is then recorded to check if there are still any free isocyanate groups left over. If this is not the case, 696 g of water and 60 g of glacial acetic acid are added as a mixture. This results in the formation of a homogeneous clear liquid, from which the solvent is distilled. The distillation is terminated once the solids content is 29%.

10 Polyurethane 3 (inventive):

168.5 g of hexamethylene diisocyanate (1.003 mol) are added to a solution of 59.6 g of N-methyldiethanolamine (0.5 mol) and 31.1 g of ethylene glycol in 250 g of acetone at reflux temperature over the course of 1.5 hours. An infrared spectrum is then recorded to check if there are still any free isocyanate groups left over. If this is not the case, 580 g of water and 31.3 g of glacial acetic acid are added as a mixture. This results in the formation of a homogeneous clear liquid, from which the solvent is distilled. The distillation is terminated once the solids content is 30.9%.

Self-dispersing isocyanate 4 (comparative):

20 85 parts by weight of an isocyanate having an NCO content of 22.5% and consisting essentially of trimeric hexamethylene diisocyanate are reacted at 60°C with 15 parts by weight of a polyethylene glycol monomethyl ether having an average molecular weight of 350. The resultant product has an NCO content of 17% and a viscosity of 1,500 mPas at 25°C. The product is very efficiently dispersible in a water-filled glass beaker simply by stirring with a glass rod. The arithmetic NCO functionality is F is 2.70.

II Finishing of wool and nonfelting test(a) Plasma pretreatment

30 Moist wool slubbing is initially subjected to a corona treatment for which the following parameters are observed:

Frequency: 23.0 Hz  
 Roll gap: 0.8 mm  
 Air supply: 400.0 l/min  
 Pulse full-cycles on: 2  
 5 Pulse full-cycles off: 8  
 Spread: 1:2  
 Forward feed rate: 10 m/min  
 Power: 780 W

(b) Wet chemical treatment

10 The moist wool slubbing pretreated according to step (a) is treated by the exhaust process with a solution of the above-described polyurethanes that is buffered to pH 5 via an acetic acid/acetate buffer. When the self-dispersing isocyanate is used, a similar procedure is carried out at a pH 7, set using a phosphate buffer.

15 The slubbing is prewetted in warm water and whirled to spin off excess water. The finishing bath of warm water at 40°C is admixed with 2% (solid, based on the wool weight in the dry state) of the respective polyurethanes while observing a liquor ratio of 20:1. The wool remains in the bath for 20 minutes and is then removed, squeezed off, washed three  
 20 times manually with water in a beaker, again squeezed off, and suspended from a line to dry.

After drying, the wool is subjected to the Aachen felting ball test of IWTO standard 20-69. The results are summarized below in Table 1:

Table 1:

Example	Aftertreatment agent	Average felting ball diameter [cm]
Inventive 1	Polyurethane 1	3.794
Inventive 2	Polyurethane 2	3.754
Inventive 3	Polyurethane 3	3.494
Comparative 4	Self-dispersing isocyanate 4	3.437

Comparative Examples 5 and 6:

In Comparative Example 5, the Aachen felting ball test is measured on the wool following a plasma treatment only, i.e., after the step (a) described above for Inventive Examples 1 to 3 and Comparative Example 4 has been carried out.

In Comparative Example 6, the wool is exclusively treated with the self-dispersing isocyanate according to the step (b) treatment described above for Comparative Example 4 and then subjected to the Aachen felting ball test.

10 A comparison of the felt densities, which are likewise measurable in the Aachen felting ball test, for the different pre- and aftertreatments of the wool slubbing is contained in Table 2:

Table 2:

Example	Antifelt finishing process	Felt density [g/cm <sup>3</sup> ]
Inventive 1	Wool, plasma treated + polyurethane 1	0.036
Inventive 2	Wool, plasma treated + polyurethane 2	0.036
Comparative 4	Wool, plasma treated + self-dispersing polyisocyanate 4	0.04
Comparative 5	Wool, plasma treated	0.11
Comparative 6	Wool, untreated + self-dispersing polyisocyanate 4	0.14